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MSHPLT DOCUMENTATION (VAX-11/750 VERSION) - A MESH PLOTTING PROGRAM FOR FINITE ELEMENT ANALYSIS

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ABSTRACT

MSHPLT **is one of the component programs contained in the *SAP2D* system. It provides the capability of plotting the two-dimensional meshes that have been generated by the program MSHGEN. This report documents MSHPLT. In particular, the files used and the input instructions needed are described. In addition, a command procedure to be used to run *MSHPLT*, for VAX/VMS system, is presented.**

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DOCUMENTATION SUR LE MSHPLT (VERSION DU VAX-11/750) - PROGRAMME DE TRAÇAGE DE RÉSEAUX POUR L'ANALYSE PAR ÉLÉMENTS FINIS

par

Y. S. Yu*, N. A. Toews* and A. S. Wong**

RÉSUMÉ

Le MSHPLT est l'un des programmes faisant partie du système SAP2D. Il permet de tracer les réseaux bidimensionnels qui sont produits par le programme MSHGEN. le présent rapport documente le MSHPLT. Notamment, les fichiers utilisé et les directives d'entrée requises y sont décrits. En outre, une méthode de commande à utiliser pour exécuter le MSHPLT, pour le système VAX/VMS est présentée.

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1.0 INTRODUCTION

Finite element analysis is used to find stresses for mine structures or other types of geotechnical structures. The structures are usually large and have complicated geometries. The discretization and proper grading of a finite element mesh is important and is an integral part of the stress analysis process.

The best way to check whether a generated finite element mesh is adequate is to plot the mesh and inspect it visually. MSHPLT is a mesh plotting program especially designed for use in conjunction with the mesh-generating program - MSHGEN [1,2]*. MSHPLT was originally developed for a CDC 6000 series computer and a Calcomp plotter[3]. The program was modified, in 1984, to run on a VAX-11/750 system, and most of the routines are now ASCII 77 Fortran standard, except for the use of 'byte' data in subroutine CHRHOL.

The command procedures described are basically designed for using with the Tektronix 4663 plotter and 4014 compatible graphic terminals. The use with a Calcomp plotter has not been tested.

Calcomp plotting software is extensively used in the program. Two routines associated with the VAX-11/750 VMS system are included; these are TIME and DATE.

The plotting program, MSHPLT, contains a number of options which enhances its usefullness and flexibility. These are:

a) A rectangular region can be specified and only elements inside this region are plotted. This allows magnifications of given areas of the mesh.

b) A rectangular region can be specified and only elements exterior to this region are plotted. This allows the user to exclude a highly refined area of this mesh.

c) Nodal numbers can be plotted. The user can specify a skip constant so that not all numbers need be plotted.

d) Element numbers can be plotted. Again a skip constant can be specified to aviod plotting all element numbers.

e) To distinguish between plotted nodal numbers and plotted element numbers the nodal numbers are plotted horizontally and element numbers vertically.

f) The user can specify a co-ordinate scale factor; if this factor is not specified it will be automatically calculated by MSHPLT.

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* Number(s) refers to cited references.

It should be mentioned that there is one restriction in the current version; this is that only one highly refined area can be excluded from the mesh plotting.

2.0 FILE USAGE

Four files are used in MSHPLT. These are as follows :-

Logical File Name	Description
FOR005	The MSHPLT input data file (input) ;
FOR006	The MSHPLT print file (output) ;
GENOUT	The file containing the mesh data generated by MSHGEN (input).
TEKOUT	Plot file for Tektronix 4014 or Tektronix 4663 at MRL.

3.0 INPUT INSTRUCTIONS

A number of plots can be made using the same MSHGEN generated mesh data (GENOUT). For instance, various rectangular areas might be selected for plotter magnification. Each plot has associated with it a Plot Parameter Card and possibly a Specified Rectangle Card in the following format. Note that 'card' means card input or card image input data. All input is list directed or free formatted (except blank cards).

a) Card No.1 : Identification Card

READ (,*†) NAME, ADRESS

NAME — Users name, up to 20 characters.

ADRESS — Users address, up to 20 characters.

Note : For free format, the character string must be enclosed by a quote ' '.

b) Card No. 2 : Plot Size Card

READ (,*) YPLTIN, XPLYIN

YPLTIN — The plot width limit in inches; default value is 10.89 inches. Note 1, at the end of the Section 3.0, will clarify how YPLTIN is related to the width of the plot paper.

XPLTIN — The plot length limit in inches; default value is 14.28 inches.

† Note : Denotes free format

c) Card No. 3 : Dummy Card

A blank card or CR‡ will do. For interactive running of MSHPLT the <CR> causes the screen to erase and a header plot is produced.

d) Card No. 4: Dummy Card

A blank card or CR will do. After viewing the plot, in interactive mode, the user forces MSHPLT to continue by entering a <CR>.

For each plot the following card(s) must be input.

e) Card No. 5: Plot Parameter Card

READ (,*) NBOUND, NSKPNP, NSKPEL, SCALE, AROT

NBOUND — A plot type indicator. It is possible to magnify a part of the total mesh by specifying a rectangle region and indicating all points exterior to the specified rectangle are to be excluded. Similarily, it is possible to exclude a rectangular region that is too refined for plotting with current scale.
NBOUND = 0, the whole region is plotted.
NBOUND = 1, only interior of the specified rectangle is plotted.
NBOUND = 2, only exterior of the specified rectangle is plotted.

NSKPNP — The nodal point number skip constant.
NSKPNP = 0, no nodal numbers are plotted.
NSKPNP = 'NSKPNP', every 'NSKPNP' nodal number is plotted starting from nodal point No. 1.
For example, if NSKPNP = 1, nodal numbers 1, 3, 5, 7,.... will be plotted.

‡ Note : A carriage return will be used when the user executes MSHPLT interactively.

NSKPEL — The element number skip constant.
NSKPEL = 0, no element numbers are plotted.
NSKPEL = 'NSKPEL', every 'NSKPEL' element number is plotted starting from element number No.1.
For example, if NSKPEL = 5, element numbers 1, 7, 13, 19,..... will be plotted.

SCALE — User-specified co-ordinate scale factor in world co-ordinates per inch. If SCALE = 0.0, then the program will calculate the scale using the values of YPLTIN and XPLTIN.

AROT — Plot rotation angle in degrees. If AROT = 0.0, MSHGEN generated x-axis and y-axis must correspond with the plotter x-axis and y-axis. If AROT = 90.0, then the axes are rotated by 90.0° prior to plotting.
Note that values of AROT other than 0.0, +90.0, or -90.0, will not work properly.

f) Card No. 6: Specified Rectangle Card

This card occurs only if NBOUND = 1 or 2. Otherwise skip to Card No. 7 and 8.

READ (,*) BND, XSPMN, XSPMX, YSPMN, YSPMX

BND — The first item on the card must be 'BND'.
Note that BND must be enclosed by a quote, i.e., ".

XSPMN — The left side of specified rectangle in world co-ordinates.

XSPMX — The right side of specified rectangle in world co-ordinates.

YSPMN — The lower side of specified rectangle in world co-ordinates.

YSPMX — The upper side of specified rectangle in world co-ordinates.

g) Card No. 7: Dummy Card

A blank card or CR‡ will do. For interactive running of MSHPLT the <CR> causes the screen to erase and the header plot is produced.

h) Card No. 8: Dummy Card

A blank card or CR will do. After viewing plot, in interactive mode, the user forces MSHPLT to continue by entering a <CR>.

Note 1 : Considerations in Selecting YPLTIN

MSHPLT selects a plotter origin 0.5 inches above the lower edge of the plot paper. The minimum x-value and minimum y-value of the region to be plotted are taken as the logical co-ordinates of the plotter origin. Thus, the whole plot will be above and to the right of the plotter origin. If SCALE is not specified, then SCALE is calculated so that the region to be plotted lies within the plotter size limits XPLTIN and YPLTIN. Normally YPLTIN will be the constraint on the plot size (if SCALE is specified, the plotted region must be within the plotter size limits or the job will abort). If only the finite element mesh (with no element numbers) is desired, then YPLTIN can have a maximum value of 0.5 inches less than the plotter paper width. Element numbers, if required, are plotted vertically upward from the 'centre' of the element. If the elements near the upper surface are small and the element numbers large, then the plotted numbers can extend beyond the mesh (the plotted height for both nodal point numbers and element numbers is 0.07 inches). If element numbers are required the maximum YPLTIN possible is the paper width minus 1 inch (the paper width - 1.5 inch will give a 0.5 inch border above as well as below).

4.0 COMMAND PROCEDURE

When the major portion of the input data for a finite element analysis is generated by the program MSHGEN, the general practice is to plot the mesh for visual inspection regarding its refinement or grading of a particular region. When MSHGEN is executed together with MSHPLT, a plot file - the plot of a mesh, will be generated.

The MSHPLT program can be run either interactively* or in a 'batch' mode. The procedure to run MSHPLT interactively will be described in Section 4.2. The MSHPLT command procedure for a 'batch' run, designed for VAX-11/750 mini-computer operating under VMS 4.0, is given in Appendix A.

To run the program MSHPLT in a 'batch' mode, the input files (MSHGEN input file and MSHPLT command file) and the plot file (if required) need to be defined through an interactive session. The command procedure checks all the files given by the user and make sure they are properly defined. At the end of this interactive session, the job is submitted for execution. The plot will be sent directly to the Tektronix 4663 plotter if the 'roll' option on the plotter is chosen; otherwise, a plot file(s) is then created and it can be displayed on Tektronix 4014 and copied onto a Versatec hard copier, or it can be plotted using the Tektronix 4663 plotter.

To access this command procedure conveniently the user should define the following in his login.com file.

$MSHPLT:==@[FE.COMMAND]MSHPLT

Then the MSHPLT command procedure can be executed merely by typing 'MSHPLT' in response to the DEC '$' prompt. An example is shown in Section 4.1.

The command procedure does the following:

a) Demands your decision whether to run MSHPLT interactively or otherwise;

b) Requests the name of MSHGEN input data file;

c) Demands your decision whether the mesh is to be plotted on the Tektronix 4663 plotter with the 'roll' option, or otherwise. If MSHGEN is run interactively, it will skip this step;

d) If the 'roll' option is not selected for the 4663 plotter, it will request the name of

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* If MSHGEN is run interactively, the user has to use Tektronix 4014 compatible terminal.

your plot file(s). The default is MSHPLT.TEK;

e) Requests the name of MSHPLT command file. This command file contains the input data as described in Section 3.0.

4.1 Example of Creating Mesh Plot Files:

The following is an example for creating the plot files using the MSHPLT command procedure. Note that the '$' sign is a DEC prompt. For demonstration purposes, the response in lower-case is the reply from the user and command procedure responses in upper-case.

****** session begins *****

```
$ mshplt
YOU ARE RUNNING MSHPLT COMMAND PROCEDURE
DO YOU WISH TO RUN MSHPLT INTERACTIVELY? (Y/N): n
INPUT MSHGEN INPUT FILE
  - DEFAULT MSHGEN.DAT: incomesh.dat
MSHGEN COMPLETE
  IS THE MESH TO BE PLOTTED ON THE 4663 PLOTTER
    WITH ROLL OPTION? (Y/N): n
SPECIFY NAME OF PLOT FILE
  THE DEFAULT IS MSHPLT.TEK: myplot.tek
ENTER NAME OF MSHPLT COMMAND (INPUT) FILE
  - DEFAULT MSHPLT.DAT: mshpltcmd.dat
```

At this phase, a series of information concerning MSHGEN execution will appear on the screen. when all the plot files are generated, a '$' sign will appear again on the screen.
$

***** session ends *****

Now, those plot files can either be plotted on the Tektronix 4663 plotter or displayed on the Tektronix 4014 terminal and copied onto the Versatec printer/plotter, if required.

To execute the plot on the Tektronix 4663 plotter or 4014 graphic display terminal, you simply turn on the device power first and do the following:

print/que=tekp myplot.tek;* *or* ***copy myplot.tek;* tekt***

Where 'tekp' and 'tekt' are the plot devices for Tektronix 4663 plotter and 4014 graphic display terminal, respectively. If you wish to plot your plot files one by one, you should specify its version number, i.e., myplot.tek;1, myplot.tek;2, etc.

4.2 Interactive Execution Of MSHPLT:

The MSHPLT program can be executed interactively, on a Tektronix 4014 graphic terminal, following the procedure as described in Section 4.1. Note that the '$' sign is a DEC prompt.

a) Execute MSHPLT command procedure

```
$ mshplt
YOU ARE RUNNING MSHPLT COMMAND PROCEDURE
DO YOU WISH TO RUN MSHPLT INTERACTIVELY? (Y/N): y
ENTER NAME OF MSHGEN INPUT FILE
  - DEFAULT MSHGEN.DAT: incomesh.dat
MSHGEN COMPLETE
MSHPLT EXECUTION

Two 5M by 14m Stopes Separated by A 5m High and 10m Wide Pillar

NUMBER OF NODAL POINTS - - - - - - - - - - 1390
NUMBER OF ELEMENTS - - - - - - - - - - - - 1300
BLANK COMMON STORAGE NEEDED - - - - 7880
BLANK COMMON STORAGE ASSIGNED - -  20000

PLOT BUFFER LENGTH - - - - - - - - 1

DATA CO-ORDINATE LIMITS
MINIMUM X-VALUE - - - - - - -  0.0000000E+00 UNITS
MAXIMUM X-VALUE - - - - - - - 0.1000000E+03 UNITS
MINIMUM Y-VALUE - - - - - - -  0.0000000E+00 UNITS
MAXIMUM Y-VALUE - - - - - - - 0.2050000E+03 UNITS
```

b) Now, enter your MSHPLT input data (command file), following the same order as described in Section 3, line by line.

c) To get out of the execution mode, simply hit 'CTRL/Z'.

4.3 Plotting on IMAGEN 8/300 Laser Printer

For debugging, checking refinement or grading of a mesh, the plot(s) should be done on the 4663 plotter with the C size option, or be done on the 4014 terminal using the full screen size (YPLTIN = 10.89, XPLTIN = 14.28. This is the default.)

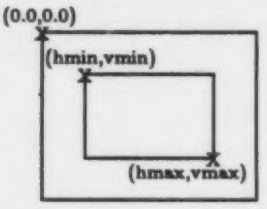
The IMAGEN 8/300 laser printer is used only when production quality plots, drawings, or figures are required for inclusion in a report. To transfer plot information to the laser printer, it is necessary to use the TEKIMP utility routine. The details on how to use TEKIMP are given in reference [4].

The following procedure is suggested to help the user to produce good quality plots on the IMAGEN 8/300 printer:

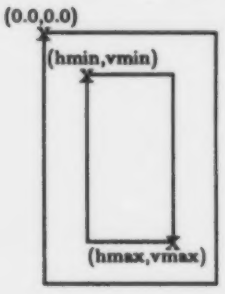
a) Execute MSHPLT, thus creating a plot file(s), say *myplot.tek*;

b) Decide on your page orientation. There are two possible page orientations - LANDSCAPE and PORTRAIT. LANDSCAPE is the default.

LANDSCAPE (28.0cm x 21.5cm):



PORTRAIT (21.5cm x 28.0cm):



c) Specify the IMPBOX= (unit,hmin,vmin,hmax,vmax), i.e., to decide where the drawing or plot is to be placed within the page (21.5cm x 28.0cm or 8.5in x 11.0in). Where unit can be cm or in; cm is centimeter, and in is inch; *hmin and vmin are the coordinates of the left upper corner of the box in cm or inches; hmax and vmax are the coordinates of the lower right corner of the box in cm or inches as shown in the two different page orientations. Note that the origin of the coordinates is located at the upper left corner of the page for both page orientations.*

d) Specify the LINEWIDTH= n; where LINEWIDTH is the thickness of lines to be plotted, n = 3 or 4 seems to be satisfactory.

e) Create an impress file: To produce an impress file with portrait orientation, simply execute TEKIMP after the '$' prompt.

tekimp/port/linewidth=4/impbox=(cm,hmin,vmin,hmax,vmax) myplot.tek

f) Print the impress file - myplot.imp: To produce the plot, simply execute the utility routine IMPRESS after the '$' prompt.

$ imp myplot.imp

5.0 SAMPLE INPUT OUTPUT

5.1 MSHGEN Input Data

The following input, in Table 1, is an example for an underground pillar study, which consists of two stopes separated by a pillar. The input data is list directed.

Table 1 - MSHGEN input data

```
Two 5m by 14m Stopes Separated by A 5m High by 10m Wide Pillar
28 8 3 3 1 0
5 10 15
20 5 20
1 3 0. 0.
2 2 5. 0.
3 2 19. 0.
4 3 100. 0.
5 1 0. 100.
6 0 5. 100.
7 0 19. 100.
8 1 100. 100.
9 1 0. 105.
10 0 5. 105.
11 0 19. 105.
12 1 100. 105.
13 1 0. 205.
14 0 5. 205.
15 0 19. 205.
```

– Table 1 continued –

16 1 100. 205.
17 2 40. 0.
18 1 0. 70.
19 0 5. 70.
20 0 19. 70.
21 1 100. 70.
22 0 40. 100.
23 0 40. 105.
24 1 0. 132.
25 0 5. 132.
26 0 19. 132.
27 1 100. 132.
28 0 40. 205.
1 1 2 6 5 0 19 0 18 1 0 0
2 2 3 7 6 0 20 0 19 1 0 0
3 3 4 8 7 17 21 22 20 1 0 0
4 5 6 10 9 0 0 0 0 1 0 0
6 7 8 12 11 22 0 23 0 1 0 0
7 9 10 14 13 0 25 0 24 1 0 1
3 10.665 10.665
8 10 11 15 14 0 26 0 25 1 0 1
3 10.665 10.665
9 11 12 16 15 23 27 28 26 1 0 1
3 10.665 10.665

5.2 MSHPLT Command File Input

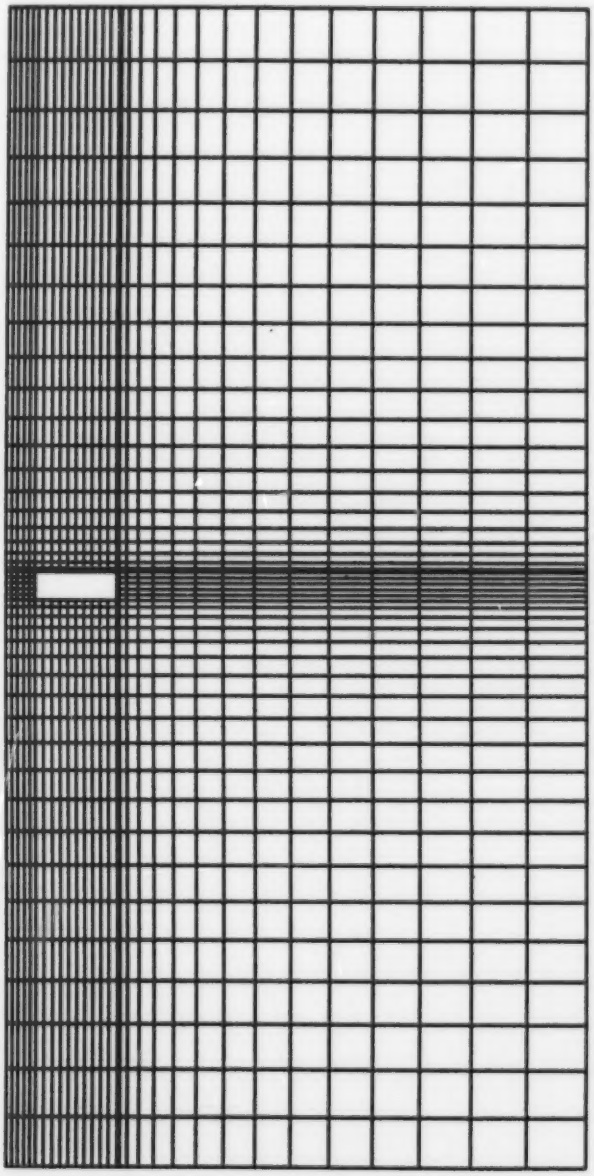
The following data, in Table 2, is used to produce the plots as shown in Figs.1, 2 and 3 in Section 5.3. Those plots were produced on a Tektronix 4663 plotter with a different scale. For this report these were replotted using an IMAGEN 8/300 laser printer.

Table 2 - MSHPLT command file input

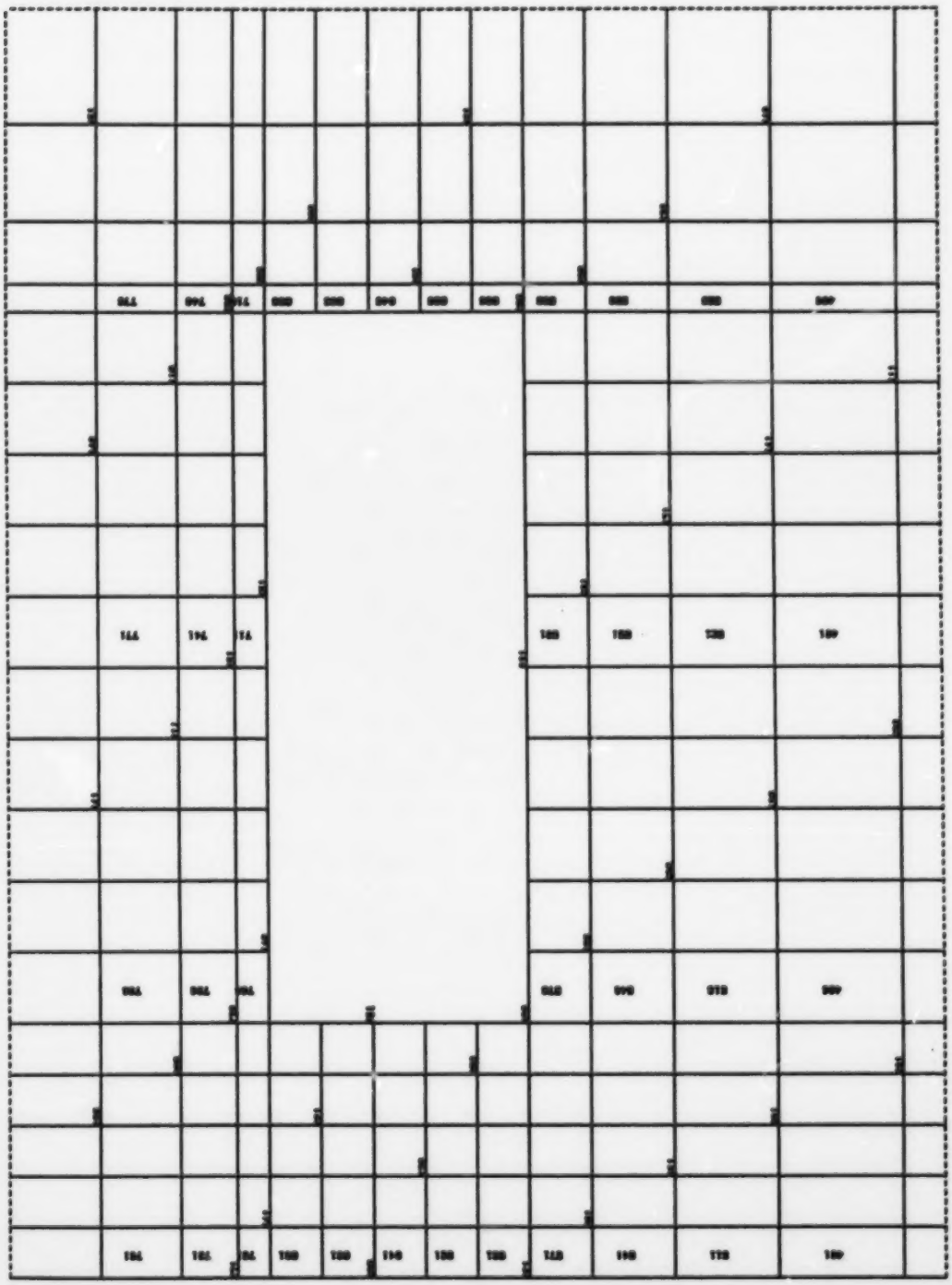
```
'MY NAME' 'MY ADDRESS'
5.0 8.0
blank line or <CR>
blank line or <CR>
0 0 0 0.0 0.0                    ***** the total mesh *****
blank line or <CR>
blank line or <CR>
1 10 5 0.0 0.0                   ***** the interior of the mesh *****
'BND' 0.0 25.0 95.0 110.0
blank line or <CR>
blank line or <CR>
2 0 0 0.0 0.0                    ***** the exterior of the mesh *****
'BND' 0.0 25.0 95.0 110.0
blank line or <CR>
blank line or <CR>
E-O-F or 'CTRL/Z'.
                                 ***** end of your input data *****
```

5.3 Plot Examples

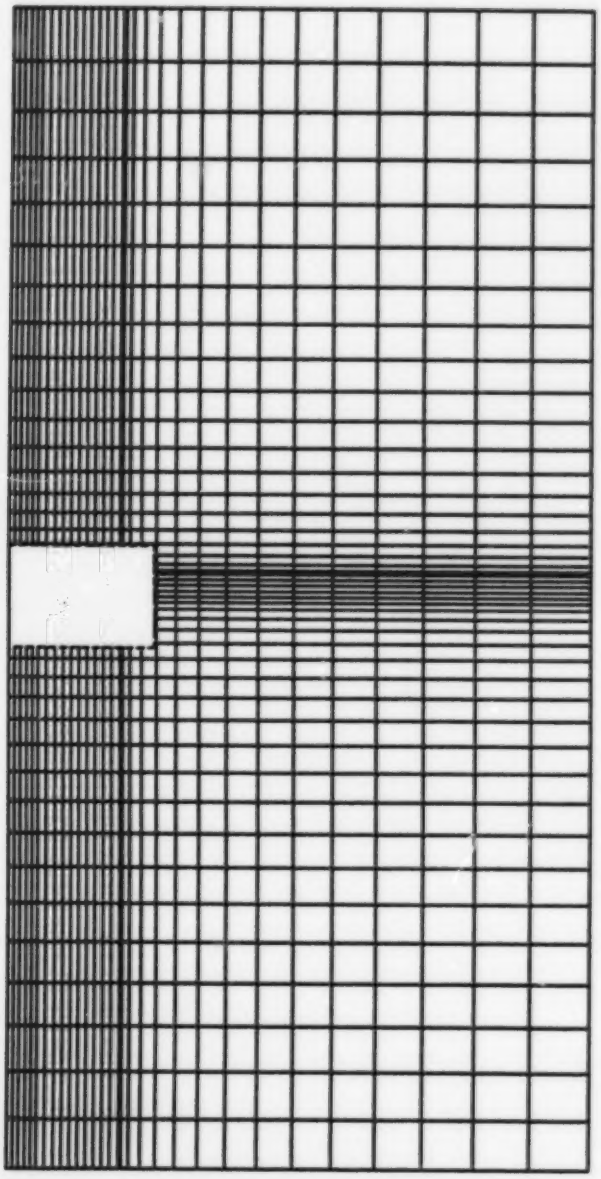
5.3.1 Figure 1 - The total mesh



5.3.2 Figure 2 - The interior of the mesh



5.3.3 Figure 3 - The exterior of the mesh



6.0 REFERENCE

1) Toews, N.A., Yu, Y.S. and Wong, A.S.; "MSHGEN Documentation (VAX-11/750 Version) - A mesh generating program for finite element analysis of two dimensional structures"; Division Report MRP/MRL 85-32 (TR); Mining Research Laboratories, CANMET, Energy, Mines and Resources Canada; Ottawa; February 1985.

2) Yu, Y. S. and Toews, N. A.; "SAP2D system - an overview"; Division Report MRP/MRL 85-95 (TR); Mining Research Laboratories, CANMET, Energy, Mines and Resources Canada; Ottawa; August 1985.

3) Toews, N.A. and Yu, Y.S.; "SAP2D documentation (1975 version) 2-D linear elastic finite element computer system"; Division Report MRP/MRL 75-109 (TR); Mining Research Laboratories, CANMET, Energy, Mines and Resources Canada; Ottawa; December 1975.

4) Toews, N.A.; "TEKIMP documentation", Report in preparation.

7.0 APPENDIX A
MSHPLT COMMAND PROCEDURE

Most of the commands given on the following page are self explanatory and will not appear on the screen during a normal interactive session, therefore, users need not be concerned with the details of those commands. However, the user should understand how these files (input and output) are defined and input. Note that the '$' sign is a DEC prompt starting in column 1.

```
$ WRITE SYS$OUTPUT "YOU ARE RUNNING MSHPLT COMMAND PROCEDURE"
$ !
$ WRITE SYS$OUTPUT " "
$ INQUIRE INT "DO YOU WISH TO RUN MSHPLT INTERACTIVELY (Y/N)"
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "INPUT MSHGEN INPUT FILE"
$ INQUIRE MSHIN " - DEFAULT MSHGEN.DAT"
$ IF MSHIN.EQS."" THEN MSHIN := "MSHGEN.DAT"
$ ASSIGN 'MSHIN' FOR005
$ ASSIGN MSHOUT.DUM GENOUT
$ ASSIGN NL: FOR006
$ !
$ RUN DISK$USER:[FE.EXECUTE]MSHGEN
$ !
$ IF INT .EQS. "N" THEN GOTO NO
$ ASSIGN SYS$COMMAND FOR005
$ ASSIGN TEKT TEKOUT
$ ASSIGN SYS$OUTPUT FOR006
$ RUN DISK$USER:[FE.EXECUTE]MSHPLT
$ GOTO FINISH
$ !
$ NO:
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT " IS THE MESH TO BE PLOTTED ON THE 4663 PLOTTER"
$ INQUIRE TEKO      "                          WITH ROLL OPTION ? (Y/N)"
$ IF TEKO.EQS."Y" THEN GOTO NEXT1
$ WRITE SYS$OUTPUT "SPECIFY NAME OF PLOT FILE"
$ INQUIRE PLOT "THE DEFAULT IS MSHPLT.TEK"
$ IF PLOT .EQS. "" THEN PLOT := "MSHPLT.TEK"
$ ASSIGN 'PLOT' TEKOUT
$ GOTO NEXT2
$ NEXT1:
$ ASSIGN PLOT.DUM TEKOUT
$ NEXT2:
$ ASSIGN SYS$OUTPUT FOR006
$ T132
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "INPUT MSHPLT COMMAND(INPUT) FILE"
$ INQUIRE PLTIN " - DEFAULT MSHPLT.DAT"
$ IF PLTIN.EQS."" THEN PLTIN := "MSHPLT.DAT"
$ ASSIGN 'PLTIN' FOR005
$ RUN DISK$USER:[FE.EXECUTE]MSHPLT
$ DELETE MSHOUT.DUM;*
$ IF TEKO.NES."Y" THEN GOTO FINISH
$ PRINT/DELETE/QUEUE=TEKP PLOT.DUM;*
$ FINISH:
$ T80
```